Status of E949 gamma analysis
$K^+ \to \pi^+ \gamma\gamma$

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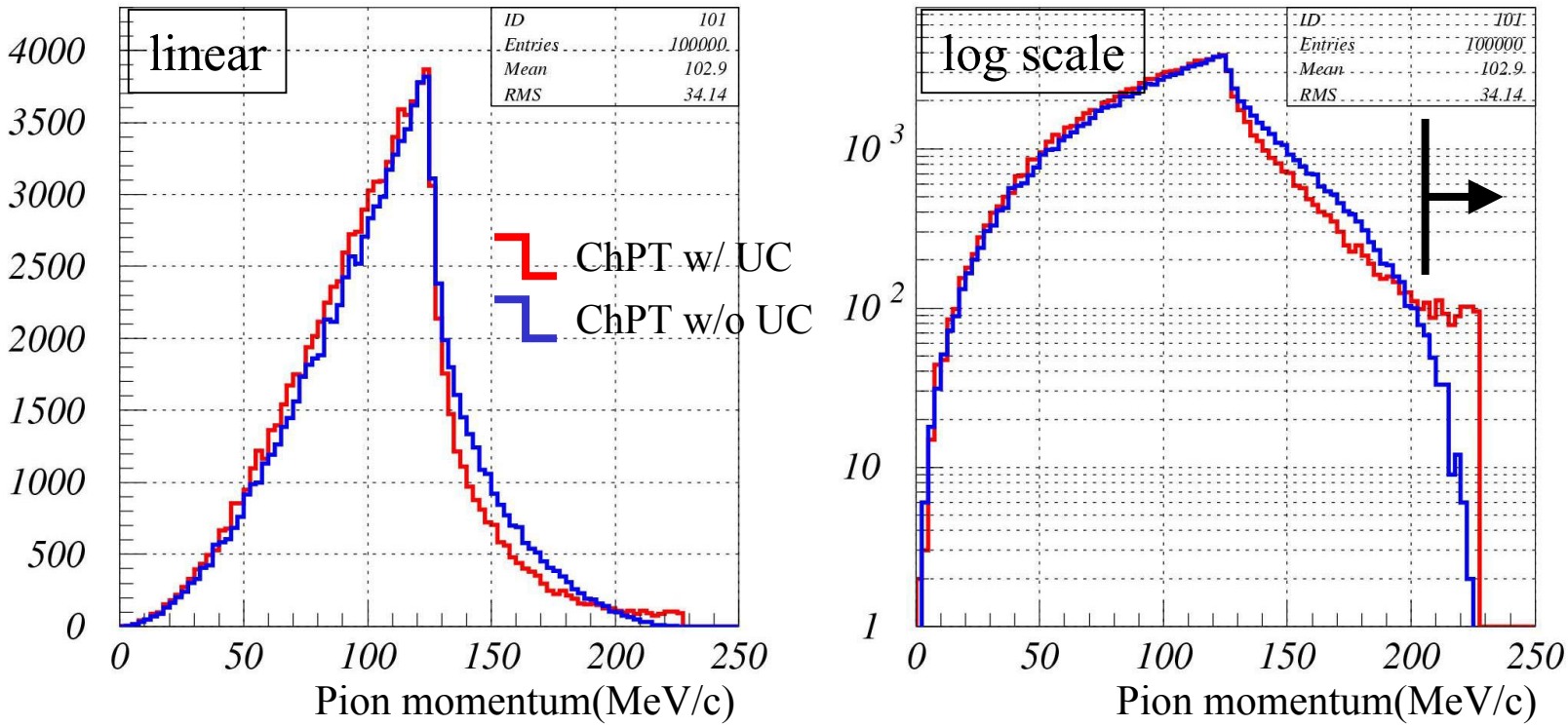
outline

1. Introduction
2. Progress since last meeting
3. Background Study(1/3 sample)
4. Summary and Future

Introduction(1)

- *Prospects for $K^+ \to \pi^+\gamma\gamma$ (1) in E949 :*
  - $K^+ \to \pi^+\gamma\gamma$ (1) region(ptot>215 MeV/c) is sensitive to the models of Chiral Perturbation Theory(ChPT).
  - We should observe 3-6 signal events if the current ChPT model is correct.



http://www.phy.bnl.gov/e949/software/meetings/030209/pdf/T.Komatsubara_E949_gamma_intro.pdf

Introduction(2)

- *Trigger acceptance using the UMC data.*

KB	999937	acceptance
T*2	449779	0.4498
6ct+7ct	374398	0.8324
16ct+17ct	40888	0.1092
online-PV	11012	0.2693
UFATE	9975	0.9058
USTOP_HEX	9934	0.9959
TOTAL		$9.935 \pm 0.099 \times 10^{-3}$

- KBL = 1.16e12
- BR(pgg1) = 5.66e-9
  (ChPT+UC, c-hat = 1.8)
- fs = 0.7
- Acc(offline) = 0.0719
  (S.Adler, E787-'91)

expected signal events

= KBL * BR(pgg(1)) * fs * Acc(trig) * Acc(offline)

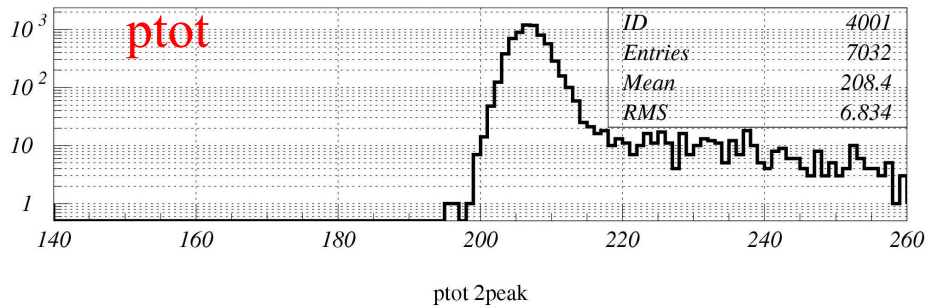
= 3.28

Progress since last meeting(1)

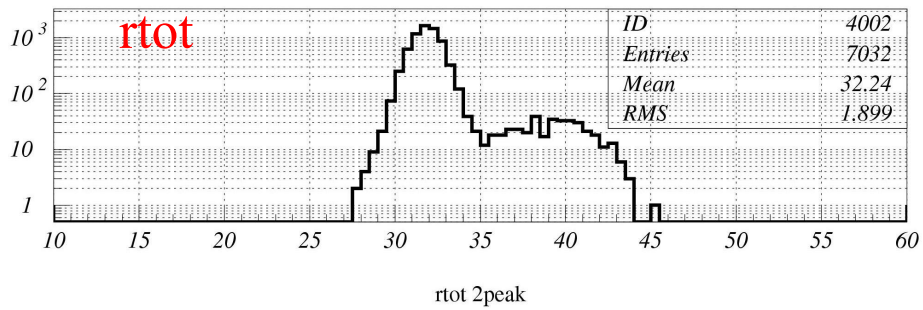
- *At the last meeting…*

  In the Kpi2 background study, a lot of events existed in the Kpi2 kinematics tail after imposed all setup cuts.

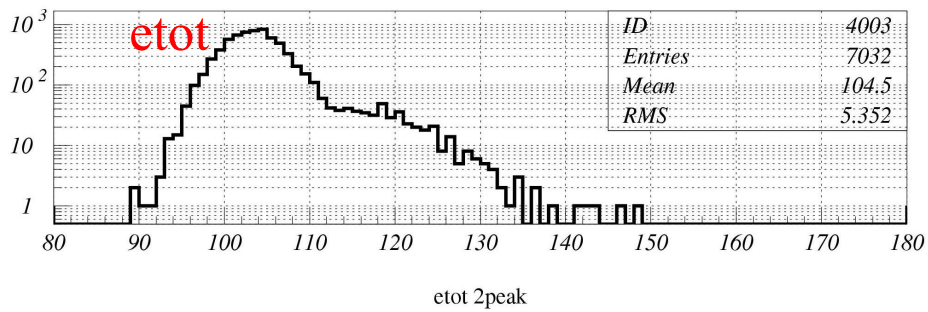
→ due to these tail events, # of backgrounds was 2.17, although it was 1/20 sample…



ptot 2peak



rtot 2peak



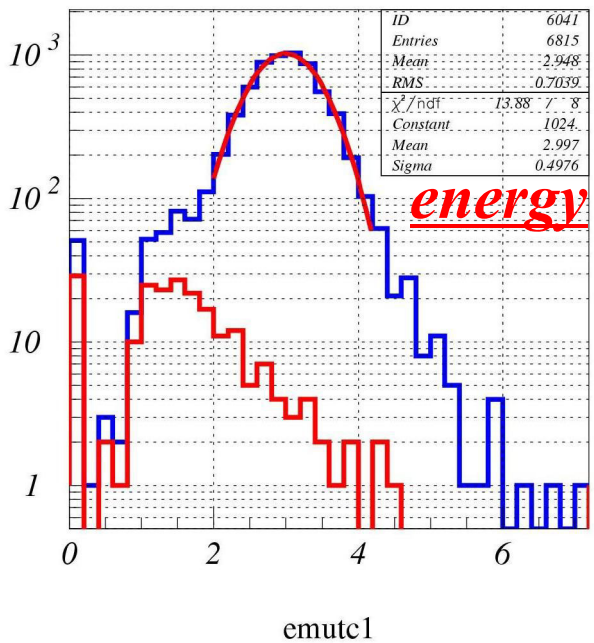
etot 2peak

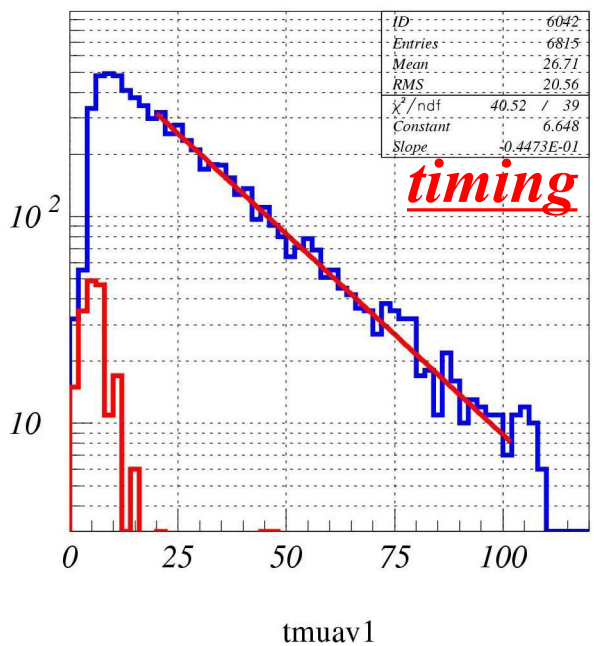
http://www.phy.bnl.gov/e949/software/meetings/030209/pdf/T.Yoshioka_kpgg.pdf

Progress since last meeting(2)

- Looking at the ‘emutc1’ and ‘tmuav1’, these events turned out to be Muon tail fluctuation background.

→ TD cut should be tighten.





tail events

Kpi2 peak events

Cuts description

- SETUP

  TRBIT, TRKTIM, UTC, RANGE1, STLAY, RSHEX,
  COS3D, ITGQUALT0, TRSLIMIT, LAY1617, TGPVCUT

- PSCUT02
- KINCUT01
- TDCUT
- BVCLS

  EG1, DIPG, COSOPXY, COSOPZ, BVCTIME

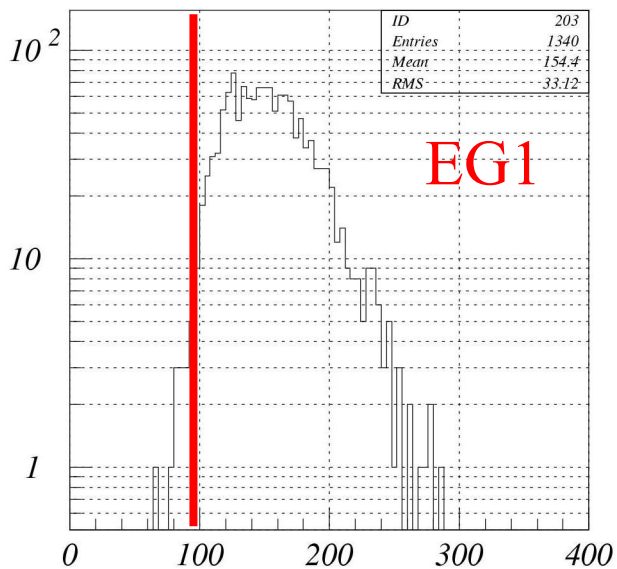
- RDPVCUT(RDPSHCUT)
- PVCUT

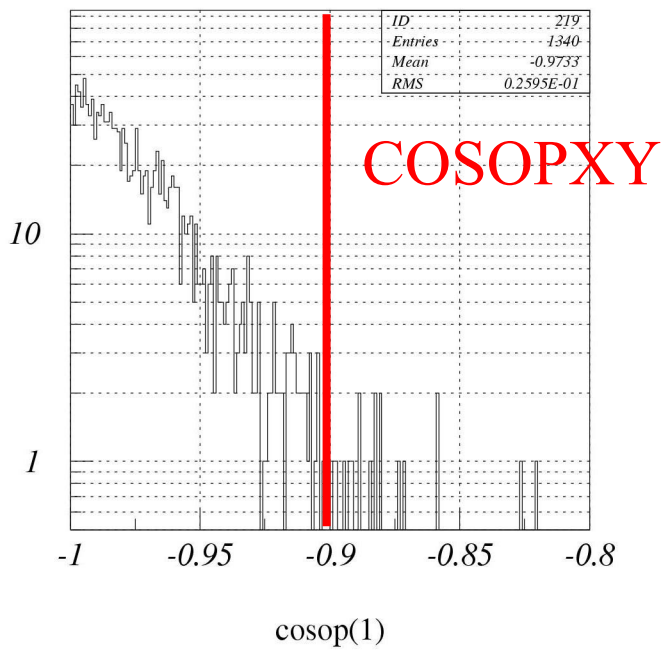
  Standard PVCUT except for the BV, BVL and RS
  TZMAX, ERAT vs COSGG

The cuts described in the red character are not standard pnn1 cut.

BVCLS

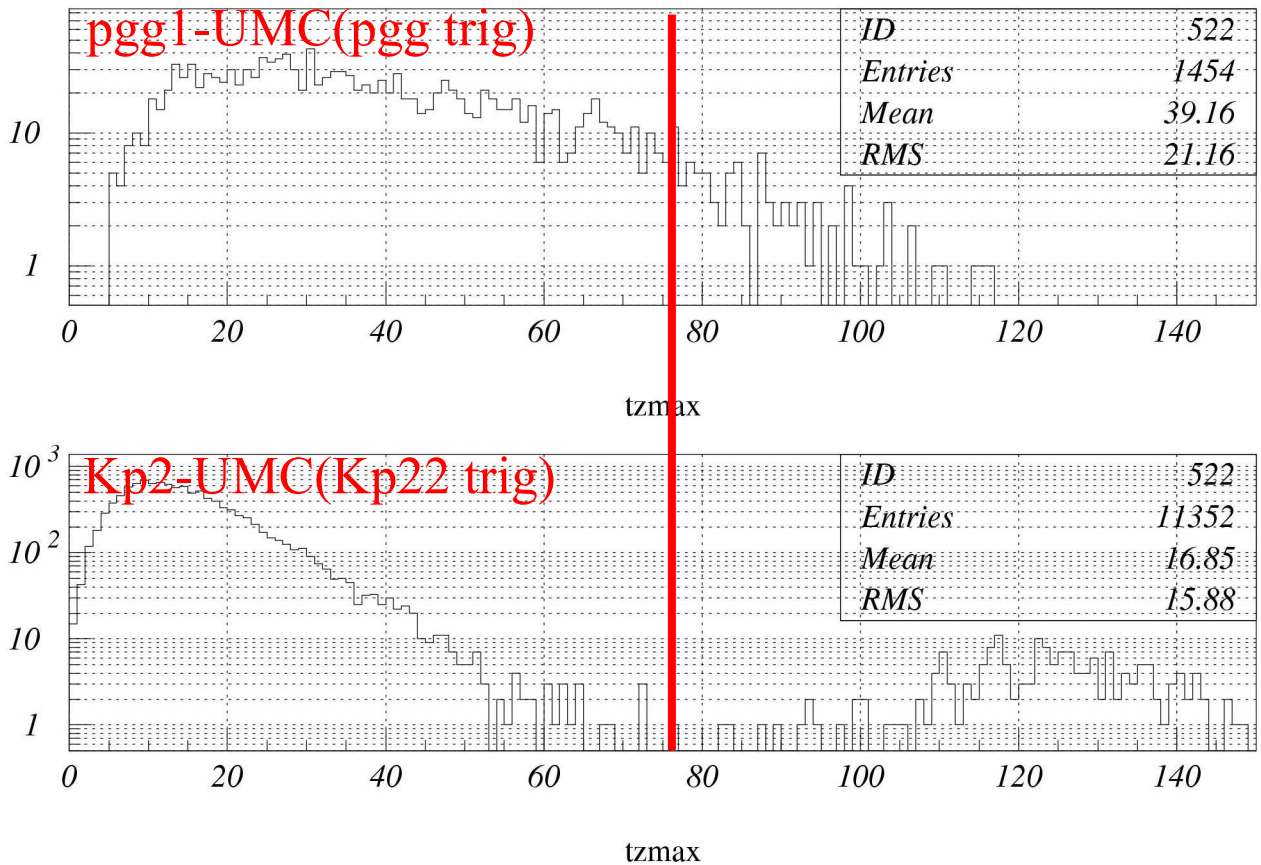
- EG1 : the energy of the highest-energy cluster(γ_1) is > 100 MeV/c.
- DIPG : $|\cos(\theta_{\gamma 1})| < 0.6$, where $\theta_{\gamma 1}$ is the dip angle of γ_1.
- COSOPXY : azimuthal opening angle is > 155deg.
- COSOPZ : polar opening angle is > 155deg.
- BVCTIME : the timing of 0.0±2.0nsec.





PVCUT(1)

- TZMAX : Veto the γ_1 cluster if the maximum discrepancy among TDC Z-measurements is > 75 cm.(might be loosen)



PVCUT(2)

- ERAT vs COSGG : cut on the photon energy ratio vs opening angle between two photons.

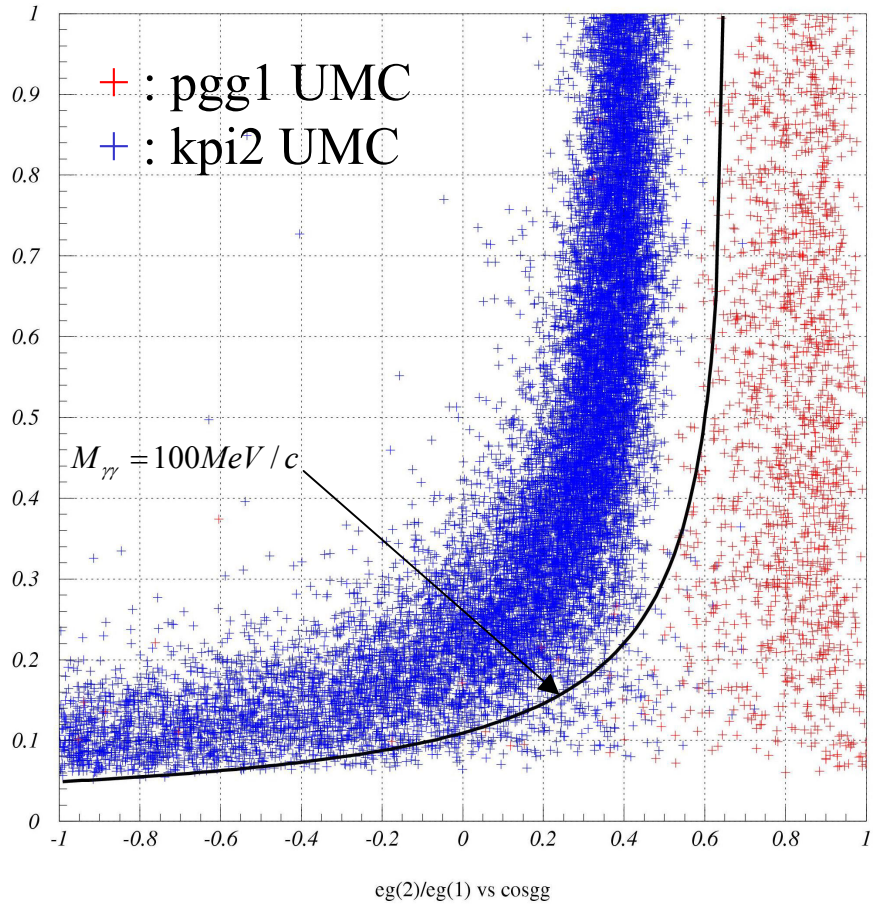
$$\frac{E_{\gamma_2}}{E_{\gamma_1}} = \frac{E_0 - \sqrt{E_0^2 - \dfrac{2M_{\gamma\gamma}^2}{1-\cos(\theta_{\gamma\gamma})}}}{E_0 + \sqrt{E_0^2 - \dfrac{2M_{\gamma\gamma}^2}{1-\cos(\theta_{\gamma\gamma})}}}$$

where

$$E_0 = \frac{M_{K^+}^2 - M_{\pi^+}^2 + M_{\gamma\gamma}^2}{2M_{K^+}}$$

current cut position

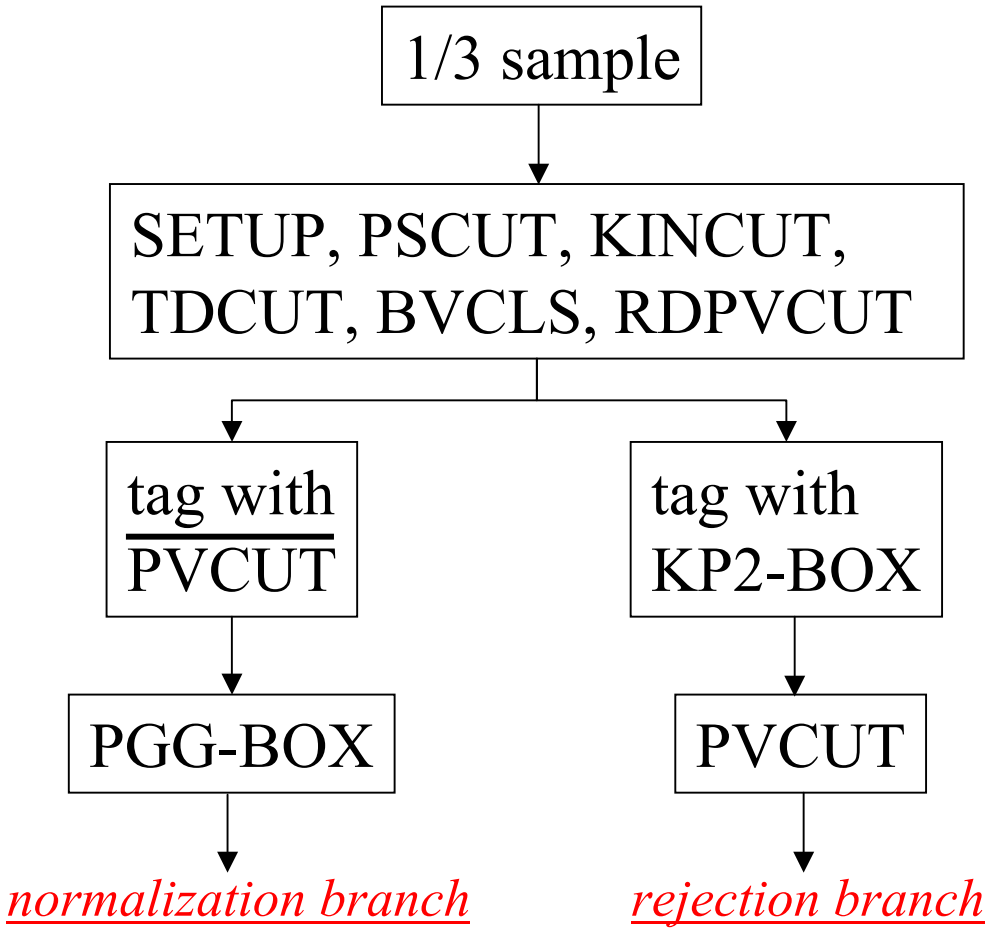
$$M_{\gamma\gamma} = 100 MeV/c^2$$



Kpi2 background(1)

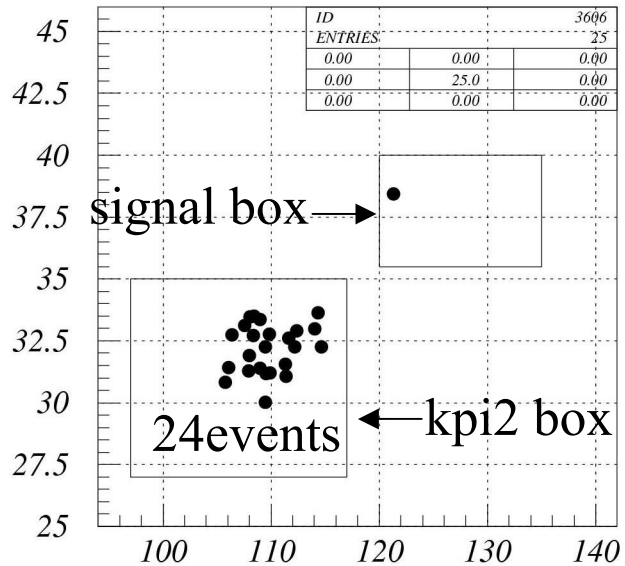
- The two cuts for the bifurcation method are :
  1) box cuts on the charged track and
  2) photon veto cuts

- signal event could be tagged by the RDPVCUT. Therefore the cut is moved to setup cut.



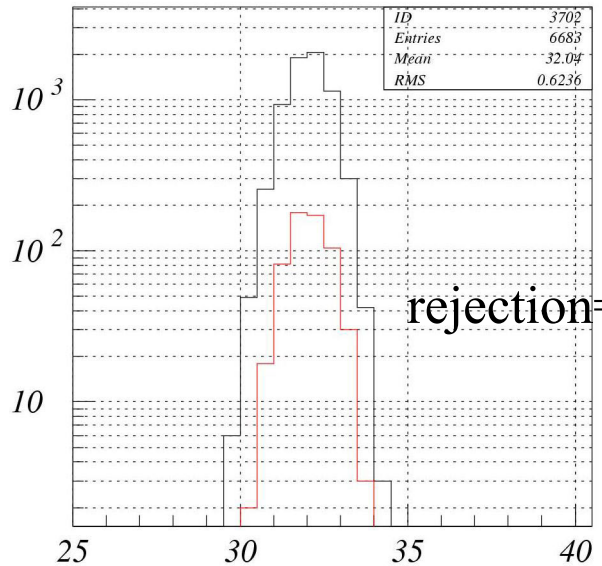
Kpi2 background(2)

normalization branch



rtot vs etot PGG-P-BOX

rejection branch



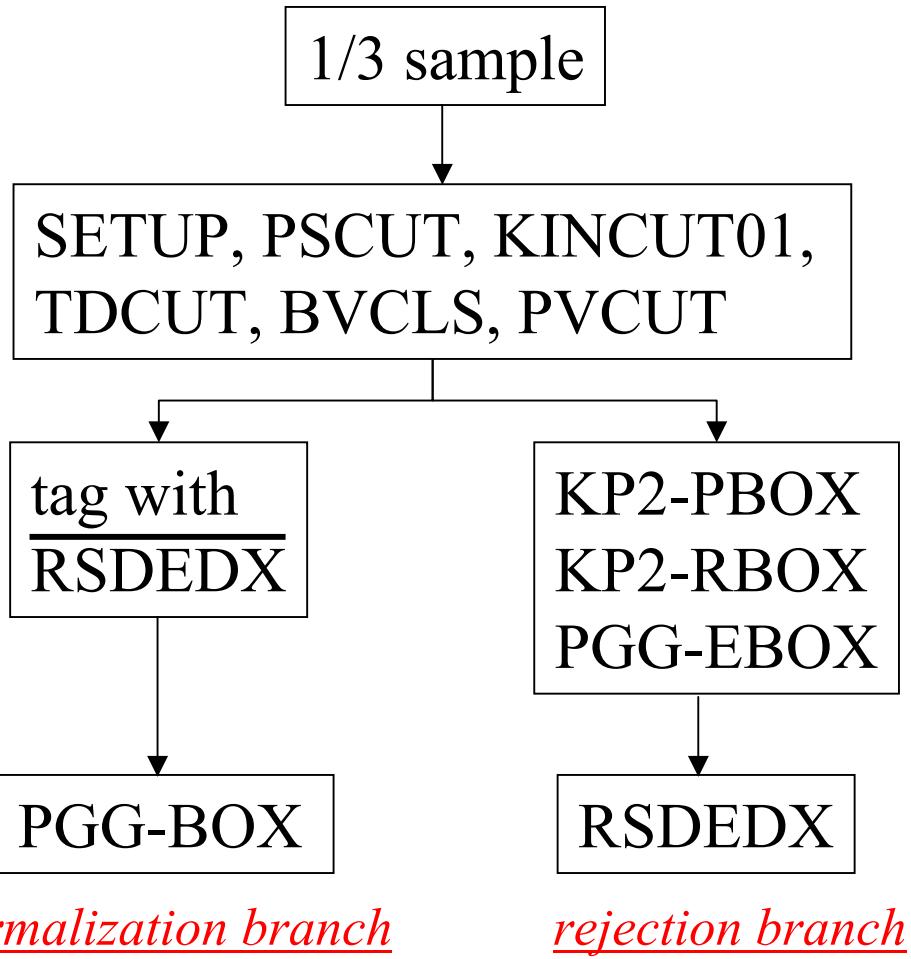
rtot KPI2BOX

- One event remained in the signal-box.
- The PVCUT rejection is 11.36.

  # of Kpi2 backgrounds = 1/(11.36-1) = 0.092

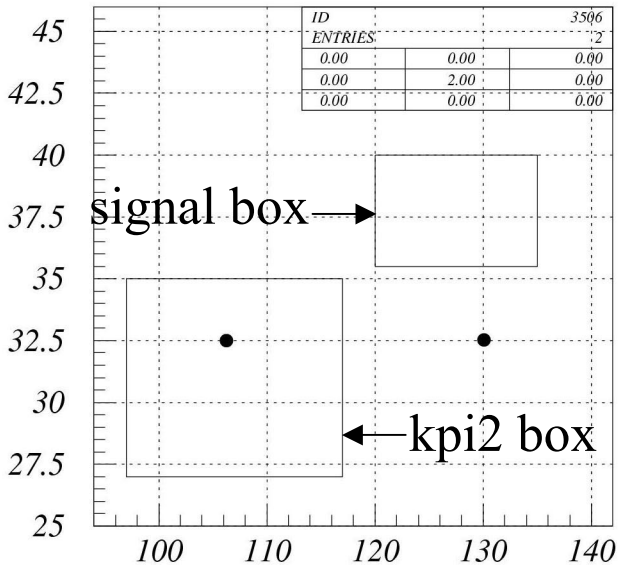
Overlapping photon background(1)

- The two cuts for the bifurcation method are :
  1) box cuts on the charged track and
  2) dE/dx cut in the Range Stack



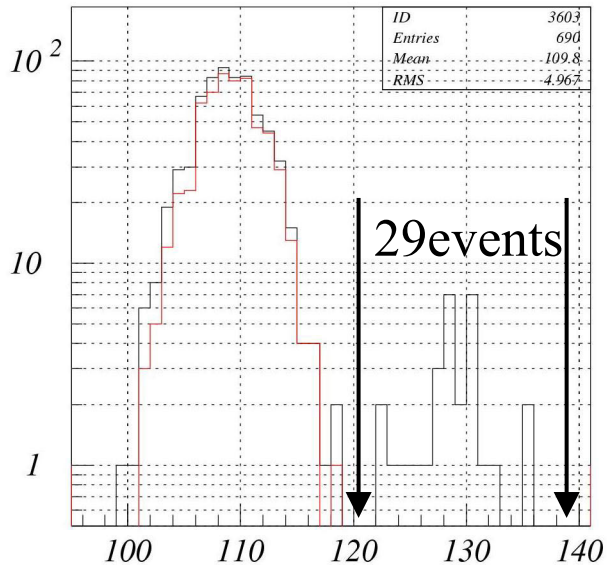
Overlapping photon background(2)

normalization branch



rtot vs etot PGG-P-BOX

rejection branch



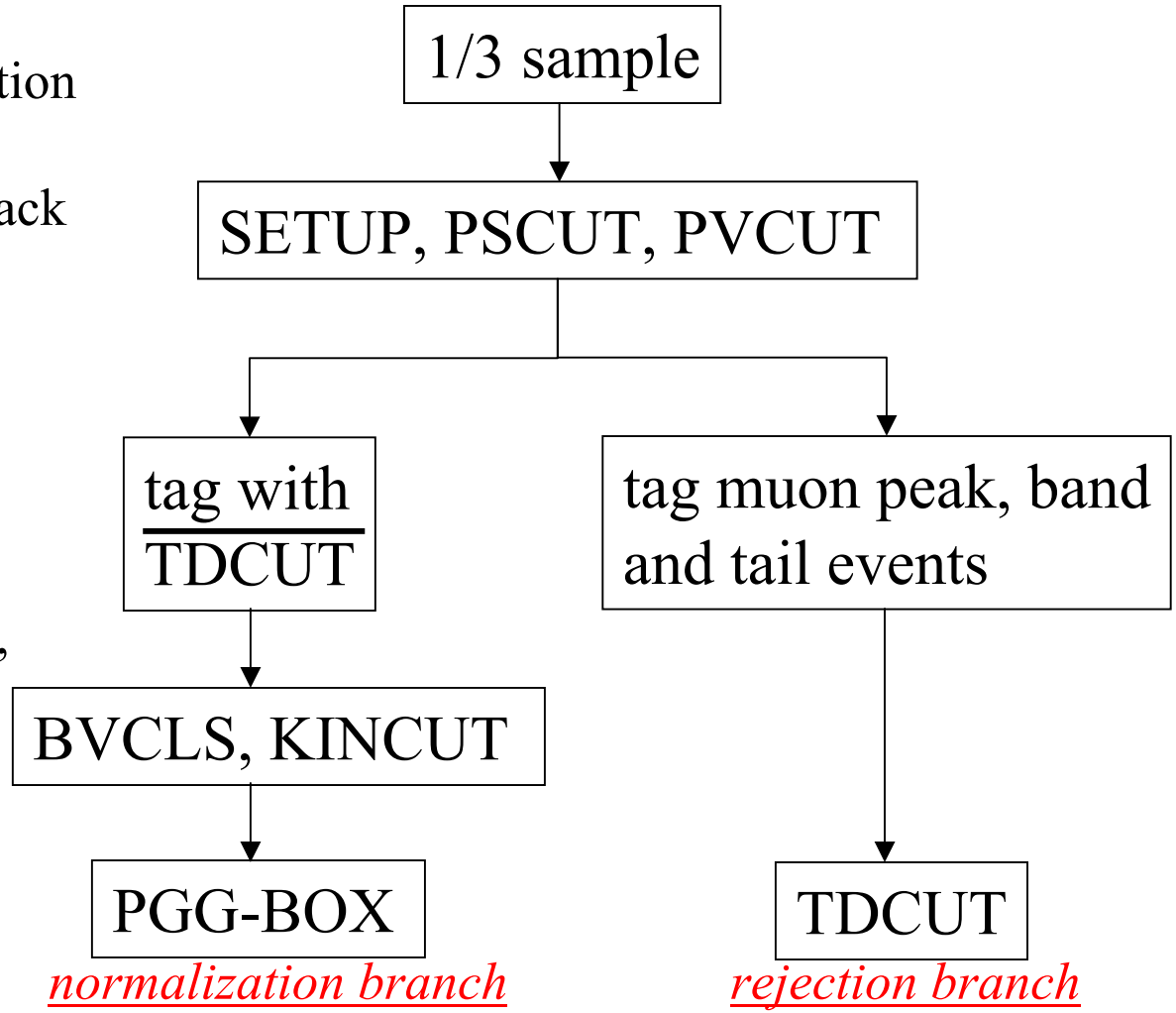
etot KP2-PR-BOX

- No event remained in the signal-box.
- The RSDEDX rejection is > 29.
  Taking 2.3 events instead of zero event :
  # of overlapping photon backgrounds < 2.3/(29-1) = 0.082(90% C.L.)

Muon background(1)

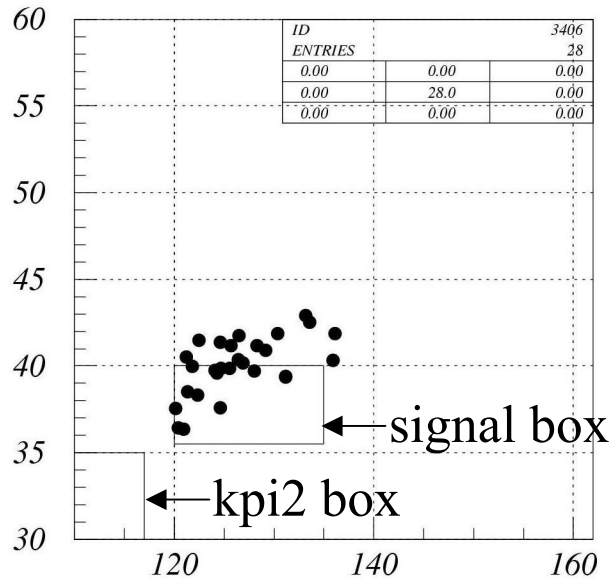
- The two cuts for the bifurcation method are :
  1) box cuts on the charged track and
  2) TD cuts

In the rejection branch, the rejections to the muon peak, muon tail and muon band are calculated separately.



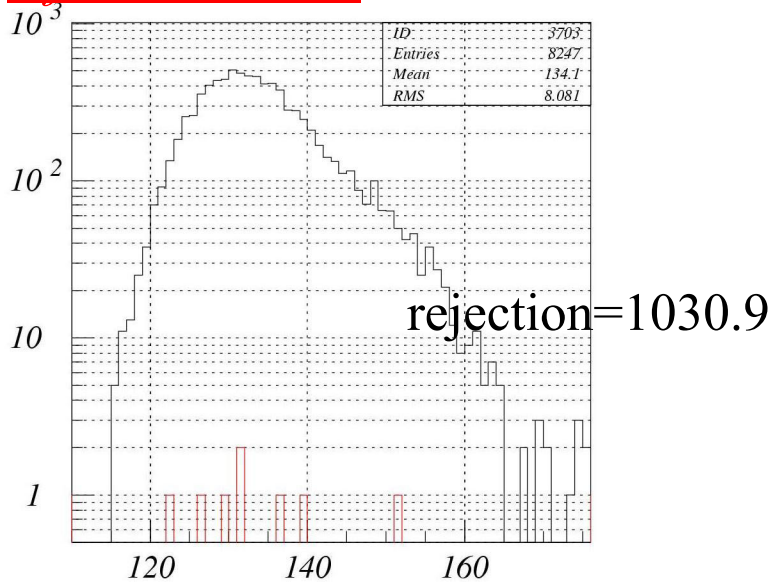
Muon background(2)

normalization branch



rtot vs etot PGG-P-BOX

rejection branch



etot PV muon-band

- 14 events remained in the signal-box.
- The TDCUT rejection is 1030.9 for band events.

# of muon backgrounds = 14/(1030.9-1) = 0.014

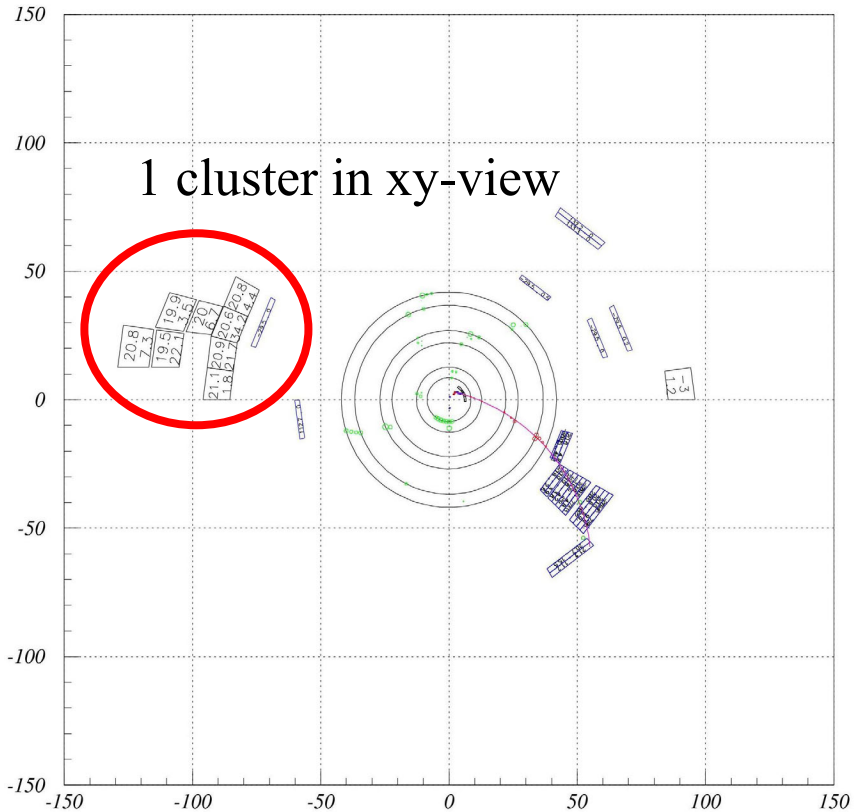
Summary of background study

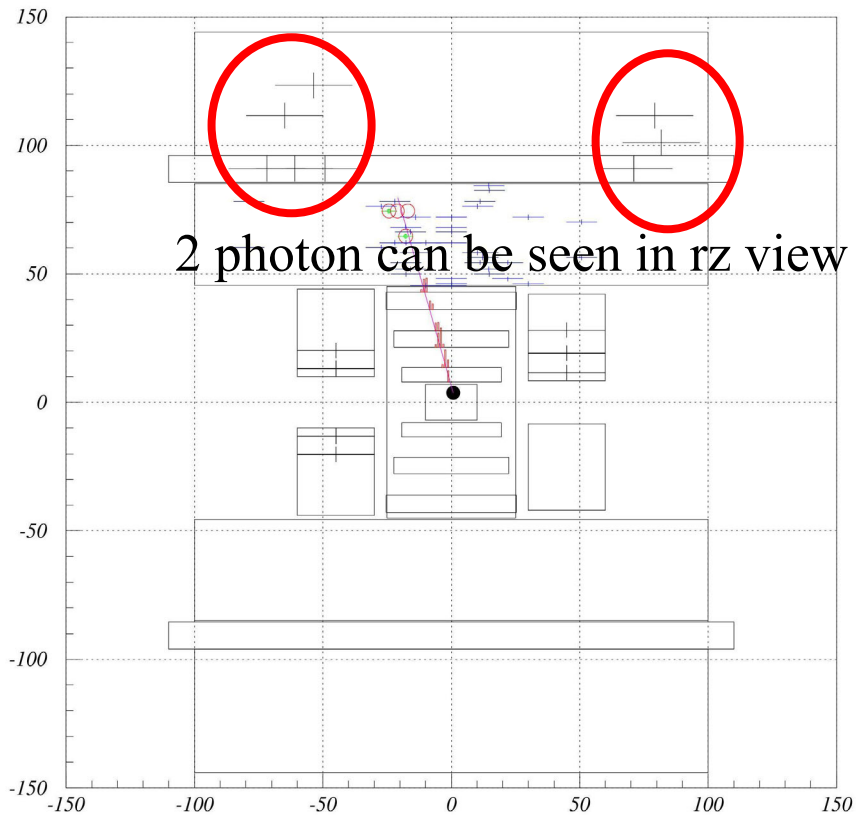
- *Using 1/3 sample*

sources	# of events
Kpi2	0.092
overlapping photon	<0.082
Muon	0.014

- Beam background is expected to be small from '97 $\pi^+\gamma$ analysis.
- Main issue is an event which remained in the normalization branch of the Kpi2 background study.

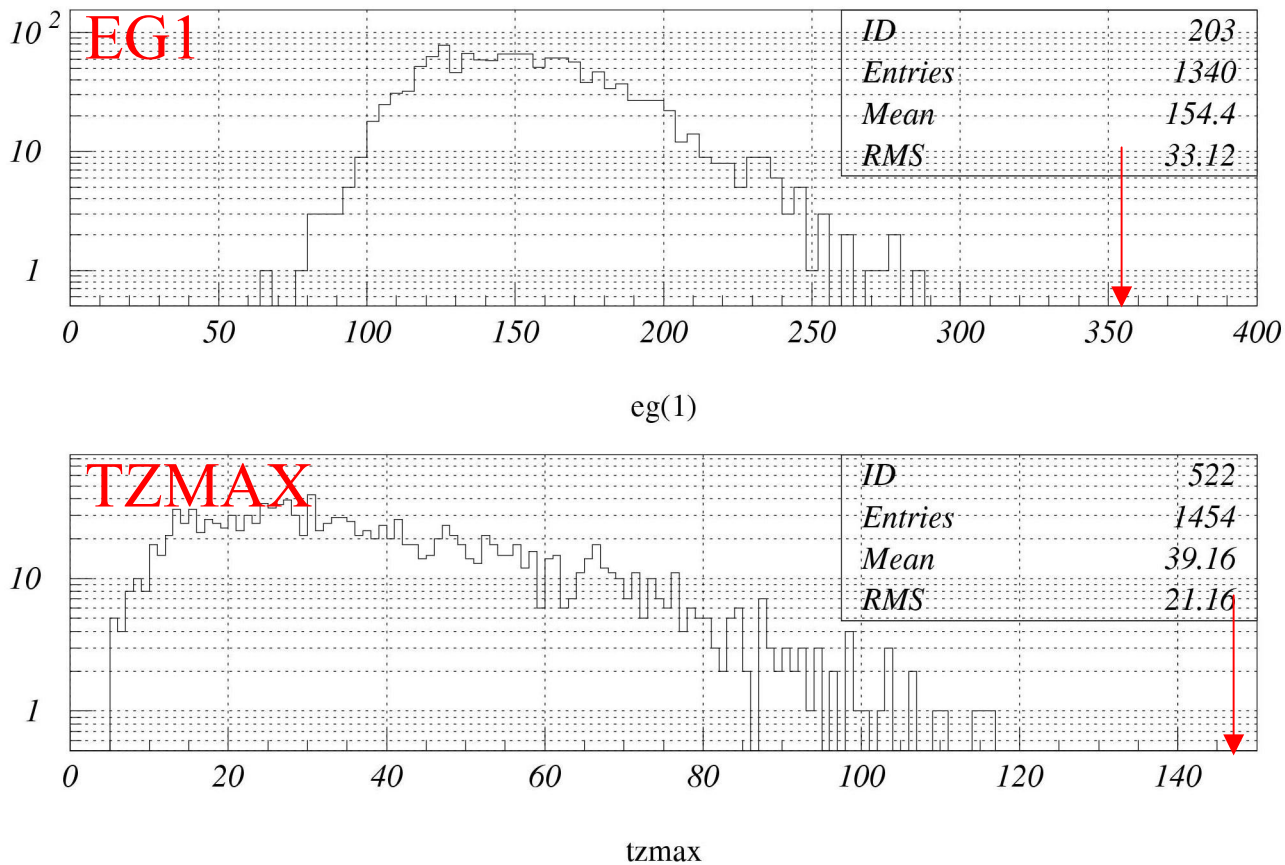
Remained event(1)





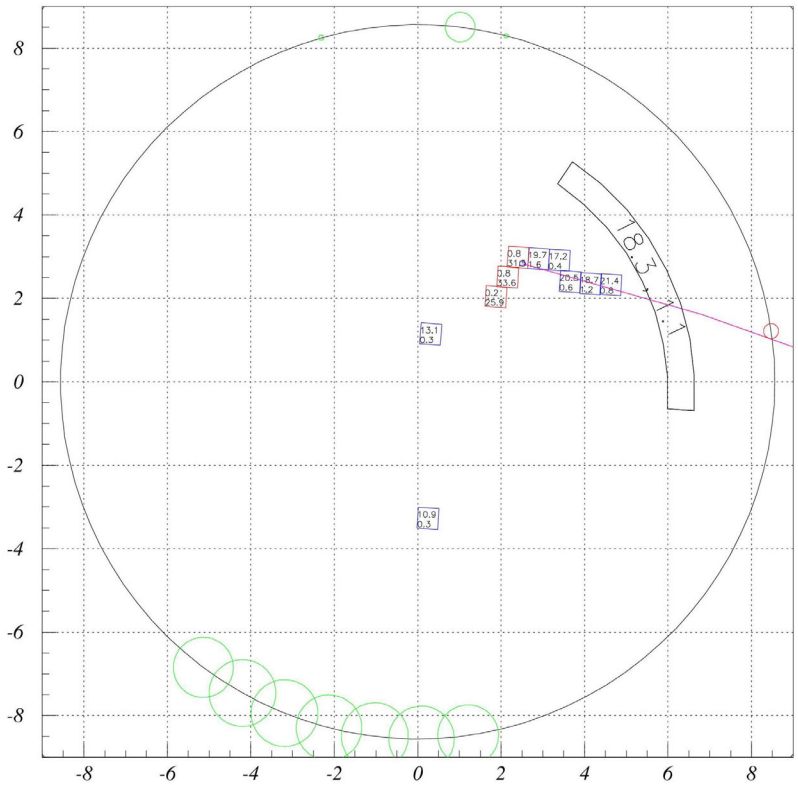
- This event seems to be Kpi2 decay, although all kinematics have higher value.
ptot = 226.9 MeV/c, rtot = 38.19 cm, etot = 120.34 MeV/c^2

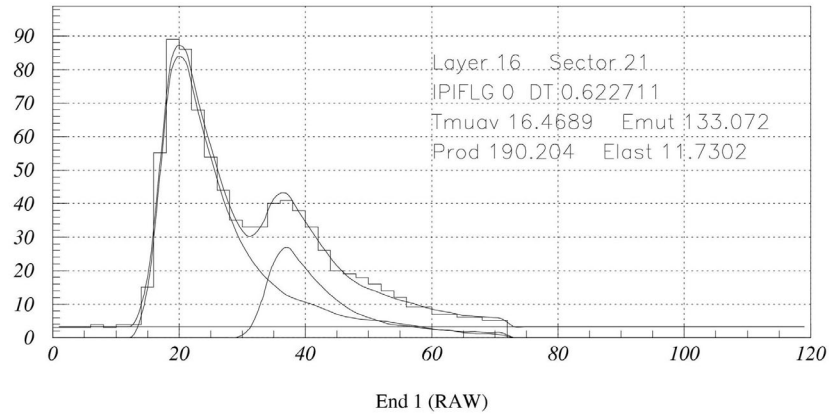
Remained event(2)



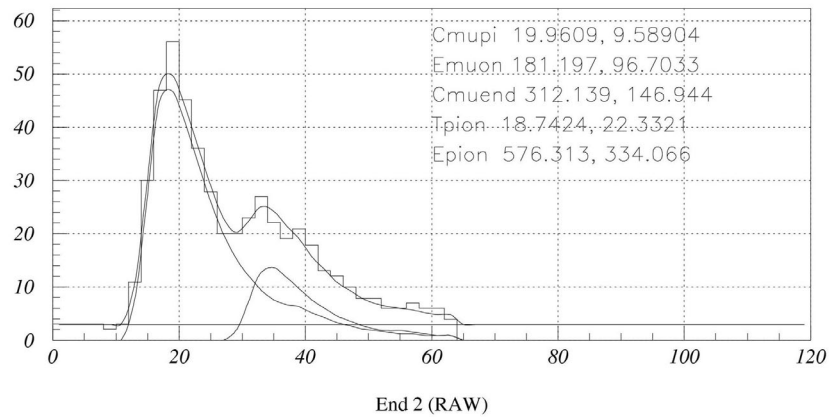
- This event is tagged by TZMAX cut and doesn't seem to be signal event.
- So far, lower bound cut for EG(1) is applied. This event can be killed be upper bound cut for EG(1)(e.g. EG(1)<300MeV/c).

Remained event(3)





End 1 (RAW)



End 2 (RAW)

- doesn't look like kaon d.i.f in the target. tpi-tk = 18.79 nsec.

- TD pulse shape in the stopping counter looks pion.

Summary and Future

- Background level is estimated using 1/3 sample.
- One event remained in the normalization branch of the Kpi2 background study.

$\rightarrow$ This event can be removed by new cut on EG(1).

TODO

- Before proceed to 2/3 study, acceptance calculation and Kinematic correction should be done.